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(19)

(72) Inventors HANSJOACHIM PASCHEDAG and THOMAS LAMPART

(54) IMPROVEMENTS IN IONIZATION FIRE ALARMS

(71) We, CERBERUS AG, a Swiss Company of Mannedorf, Switzerland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a fire-detector device including an ionization chamber accessible to the air and comprising at least one radio-active source for the generation of ions and two potential-receiving electrodes, between which there flows an ionization current of which the magnitude diminishes in the presence of smoke and/or combustion aerosols.

Arrangements of this kind made use of as fire detectors make use of the fact that the ions generated in an ionization chamber attach themselves to smoke particles or combustion aerosols and thus reduce the mobility of the charged particles. The reduction in the ionization current between the electrodes thus serves as an indication of the presence of the products of combustion resulting from a fire and for the giving of a fire-alarm signal.

Previously known ionization fire detectors, however, have the disadvantage that the ion current is affected not only by the foreign particles, but likewise by movement of air within the ionization chamber. This has a particularly disturbing effect if the velocity of the air is of the same general magnitude as the mobility of the air ions. The mobility of the air ions in the electric field at normal atmospheric pressure depends in part upon the nature and charge of the ions. For a value E of the electric field strength it may be assumed that the velocity of migration of the ions is expressed by:

$$v/E \approx 2 \text{ cm}^2/\text{Vs}.$$

While in older ionization fire detectors operating at high voltages the electric field strengths were of the order of magnitude of more than 50 V/cm and the ionic mobility therefore in the range above 1 m/s, so that the fire alarm was not subject to appreciable disturbance by air velocities of less than 1 m/s, for modern low-voltage ionization fire detectors with increased sensitivity the field strength is in the range of less than 5 V/cm. The migration velocity of the air ions then amounts to only about 10 cm/s. As is schematically represented in Figure 1 of the drawings, even an air velocity of 50 cm/s is sufficient to effect lateral transport of ions formed in the interspace between the electrodes 1 and 2 by the radio-active source 3 by a distance equal to five times that through which they move under the influence of the electric field. It will be readily understood that in this manner the larger part of the ions formed may be blown out of the ionization chamber even at low-air velocities and will no longer reach the electrodes. This leads, in the same manner as for the entry of smoke into the ionization chamber, to a reduction in the ion current and therefore to the production of an erroneous fire alarm signal.

Since in practice some flow of air is always present, e.g. from fans or air conditioners, or through draughts as a result of windows or doors being opened, such known low-voltage fire alarms with open ionization chambers can therefore be used only to a limited extent, and an installation for the supervision of ventilating ducts or in connection with exhausting devices is in general unthinkable.

However, various constructions are already known which retard the air upon its entry into the ionization chamber of an ionization fire detector to a velocity such that the described disturbances and the giving of false alarms is avoided. This must however be bought at the price of hindering and delaying the entrance of smoke into the ionization chamber. As a rule, therefore, ionization fire detectors provided with a so-called windscreen respond to an outbreak of fire only after a certain time-delay which is extraordinarily undesirable in practice.

The object of the invention is to avoid, wholly or in part, the disadvantages mentioned above and to provide an ionization fire detector in which the ion current varies only slightly even at high air velocities, and

in which smoke and combustion aerosols can enter the ionization chamber with time delay. Such an ionization fire detector should provide reduced liability to false alarms and a reduced time of response to an outbreak of fire.

According to the present invention there is provided a fire-detector device including an ionization chamber accessible to the air and comprising at least one radioactive source for the generation of ions and two spaced-apart electrodes provided with means whereby potentials may be applied thereto, whereby in use there flows therebetween an ion current of which the magnitude is reduced by the presence of smoke and/or combustion aerosols in the ionization chamber, the radioactive source or sources being contructed and arranged so that its ionization region includes a portion only of the spaced between the electrodes, whereby ion current normally flows between portions only of the electrode surfaces, and the electrodes extending from the ionization region in the direction of air flow in use through a distance equal to at least five times their separation.

The invention will now be explained with reference to embodiments which are illustrated by the drawings, in which:—

Figure 2A is a schematic longitudinal cross-section through an embodiment of fire detector;

Figures 2B—2D are scrap perspective views of portions of modified embodiments generally similar to that of Figure 2A;

Figure 3A is a perspective view showing the general form of another embodiment;

Figure 3B is a schematic diametrical cross-section of the embodiment of Figure 3A; and

Figures 3C and 3D are scrap sections illustrating modified embodiments otherwise generally similar to Figure 3B.

In the embodiments illustrated by Figures 2A—2D the air to be investigated is sucked from the space to be supervised through an air duct or ventilating shaft 4 by means of a fan or exhauster 5. At a suitable position in the air duct 4 is arranged an ionization chamber 6 serving for the detection of smoke and/or combustion aerosols. It contains two longitudinally extending electrodes 7 and 8, preferably impermeable to air ions, to which different potentials are applied. At the intake end of the ionization chamber there is arranged on each of the two electrodes 7, 8 a radioactive substance 9, 10, respectively. For the present purpose radioactive beta or alpha radiators with a short range (less than 2 cm) of the order of magnitude of 1 cm are particularly suitable, for example, tritium-containing foils, but however, other radioactive radiation sources known for use in other ionization chambers, such as Ni^{63}, Kr^{85} or Am^{241} may also be employed, though preferably the range is reduced to the desired amount by a radiation-absorbing covering. Since in the described embodiment the distance between the electrodes amounts to some 2 cm, it is ensured in this manner that the air is ionized only within an intake zone R of the ionization chamber. An extension of the ionization range in the direction of flow towards the rear is prevented on the one hand through the short range of the radioactive radiation; on the other hand the range may also be limited to the space between the electrodes by additional measures, e.g. by an inward projection 11 formed on the electrodes.

Since the extracted air flows through the air duct and thus through the ionization chamber 6 with a substantial velocity, which may be of the order of magnitude of a few metres per second, a substantial part of the air ions generated in the ionizing region at the input of the ionization chamber receive in addition to the component of velocity imparted by the electric field a velocity in the axial direction which may be larger by a multiple than the natural velocity of migration in the electric field. However, the electrodes 7 and 8 extend so far downstream that even in this case the air ions formed still reach the electrodes, not only for relatively slow laminar air-flow but also for turbulent air-flow, in which the air ions receive further rapidly increasing components of velocity in the radial and peripheral directions. It is assumed that the two electrodes extend sufficiently far in the direction of air flow. In general it is sufficient for the lengths of the electrodes to be equal to five times, or at most 10—20 times their separation, in order to collect the greater part of the deflected ions. It is thus arranged that despite substantial air velocities within the ionization chamber the ion current deviates only slightly from the normal.

The operation above described may be additionally enhanced if the ends of the electrodes are formed with a sharp edge and bent inwardly as shown at 12, so that an increased field-strength is produced in the gap between the electrodes, ions passing into this gap thus being more readily captured.

In air ducts of circular cross-section it is advantageous, for improved utilization of the extracted air, that the two electrodes are formed as part-cylindrical shells, as illustrated in Figure 2B.

The ionization chamber illustrated in Figure 2C, with a tubular cylindrical sheath as outer electrode 13 and a centrally arranged wire or pin 14 as the counter-electrode is likewise suitable for use in cylindical extraction tubes. This arrangement is conveniently provided with a single radioactive preparation 15, which is placed as a shell surrounding the central electrode 14 at the inlet of the ionization chamber, and of which the

radiation extends more or less to the outer electrode 13.

Instead of collecting residual air ions at the outlet of the ionization chamber by means of increased field strength, as described with reference to Figure 2A, there may be employed, as illustrated in Figure 2D, for the case of a cylindrical ionization chamber with a central electrode, an electrostatic collector arrangement in the form of charged air-permeable grids 16, 17 for collecting the residual ions from the air flow passing therethrough.

The invention may be employed not only in air ducts, where relatively high rates of forced air flow occur, but also with advantage even in ionization fire detectors of the kind in which air enters the ionization chamber by convection. It is well within the range of possibility that, in the spaces supervised by such ionization fire detectors, air flows with velocities of up to some 1 metre per second may appear, which may give rise to a false alarm in the case of low-voltage ionization fire detectors with open ionization chambers.

Since the direction of flow is not predetermined, however, as in extraction systems, it is advantageous in this case to employ a radially-symmetrical construction of the ionization fire detector with two extensive disc-shaped electrodes, which are arranged at a small separation from one another and with a centrally arranged radioactive source, which ionizes only a closely limited central region between the electrodes, as is shown in the embodiment illustrated by way of example in Figures 3A and 3B.

To a base 20 with an alarm indicator device 21, e.g. a light-emissive diode, is releasably secured by means of electrical contacts 23 the alarm unit containing the actual ionization chamber.

The alarm unit 22 is built on an insulating plate 24, which carries a housing 25, the side walls of which are constructed as a grid 26 permitting the entry of ambient air into the ionization chamber. In the interior of the housing 25 are placed two electrodes 28 and 29 constructed in the form of circular discs. They are held in their positions by a central post or support 27 of insulating material fixed to the insulating plate 24 and also by rods or pegs 32. The separation between the two electrodes is of the order of magnitude of 1 cm or less. Their diameter amounts to a multiple of this distance, preferably more than 10 cm but in any case so that they extend not less than five times their separation beyond the ionization region. A radioactive source 31 is arranged in a groove on the central post 27 as an annular foil. Preferably a source with a range of the order of magnitude of 1 cm is employed, e.g. a tritium compound. It is thus arranged that only a closely restricted central zone R of the ionization chamber 30, with a diameter of about 2 cm is ionized, while substantially no ionization current normally flows in the remaining part of the ionization chamber when there is little movement of air. The voltage between the electrodes preferably amounts to 5V or less, in order to produce as favourable a field strength as possible.

Under normal conditions, the described ionization fire detector operates similarly to previously known devices, that is, with slowly entering smoke-containing air the ion current is delayed and gives rise to an alarm signal by way of an electric circuit arranged for the most part on the insulating plate 24. While in known fire detectors the ion current varies substantially, however, as soon as even only a small movement of air occurs, this is not the case in the described construction. The air ions produced in the central ionizing region R are transported by the flow of air through a certain distance radially outwardly; however, with sufficient extent of the electrodes from the ionization region of at least five times their separation, the ions still fall upon the electrodes so that the ion current is only slightly dependent upon the velocity of movement of the air. In contrast to the known constructions, no wind-screening means are necessary and the ionization chamber 30 can be substantially open to the external atmosphere.

Here also, in order to increase the efficiency at the edges of the electrodes 28 and 29, field-strength increasing means, e.g. bent edges, added pins or, as shown, annular projections 33, may be provided or the grid 26 may be electrostatically charged.

Because of the small electrode separation and the high internal impedance of the ionization chamber 30, as good as possible insulation between the electrodes is particularly important. This can be arranged by leakage-path extending ribs 34 on the central post 27, as is shown in Figures 3C and 3D. Instead of securing both of the electrodes to the central post 27, one of the electrodes may alternatively be secured to pegs such as 32 on the insulating plate 24, which still further improves the insulation.

Instead of being placed on the central post 27, the radioactive preparation may alternatively be placed on one of the two electrodes in the form of a wire ring, which may for example be sunk in a groove as shown in Figure 3D.

The central post 27 may be provided with a central bore, through which a connection is produced between the electrode 29 and a field-effect transistor 35, or other voltage-sensitive device, which is arranged on the back of the insulating plate 24 and is advantageously encapsulated. In the manner described above, despite the small dimensions, a reliably operating wind-insensitive but highly sensitive and rapidly responsive ionization fire detector is provided.

In all of the embodiments described it is usually advantageous to choose the electrode spacings and potentials so that the ionization chamber operates just at the beginning of its saturation range, or just below, i.e., so that in the normal case almost all of the ions formed reach the electrodes, without any substantial proportion being lost by recombination. If necessary, the working point may be chosen so that a reduction of ion current from the blowing of ions out of the chamber is exactly compensated by the reduced recombination rate due to the effect of the wind. In addition, the sensitivity to smoke is then fully maintained, since for smoke particles and aerosols, because of their lower mobility and their substantially higher recombination probability in comparison to air ions, the ion current saturation first appears only at higher voltages. In this manner there is thus provided an ionization fire detector which is substantially wind-independent and of which the smoke sensitivity and rapid response behaviour are nevertheless retained.

WHAT WE CLAIM IS: —

1. A fire-detector device including an ionization chamber accessible to the air and comprising at least one radioactive source for the generation of ions and two spaced-apart electrodes provided with means whereby potentials may be applied thereto, whereby in use there flows therebetween an ion current of which the magnitude is reduced by the presence of smoke and/or combustion aerosols in the ionization chamber, the radioactive source or sources being constructed and arranged so that its ionization region includes a portion only of the space between the electrodes, whereby ion current normally flows between portions only of the electrode surfaces, and the electrodes extending from the ionization region in the direction of air flow in use through a distance equal to at least five times their separation.

2. A fire-detector device in accordance with claims 1 for inclusion in an air duct so that air flows through the ionization chamber, wherein the radioactive source is placed at the position at which the air enters the ionization chamber and the electrodes extend from the ionization region in the direction of air movement by a distance equal to at least ten times their separation.

3. A fire-detector device in accordance with claim 1 or claim 2 wherein each electrode has the form of part of a hollow cylinder, or one electrode has the form of a complete hollow cylinder and the other electrode is a wire or pin arranged centrally therein.

4. A fire-detector device in accordance with any one of the preceding claims wherein means increasing the field strength between the electrodes are provided at the position at which the air leaves the ionization chamber.

5. A fire-detector device in accordance with any one of the preceding claims wherein at least one air-permeable grid arranged to be electrically charged is provided at the position at which the air leaves the ionization chamber.

6. A fire-detector device in accordance with claim 1, wherein the two electrodes are formed as plates, the radioactive preparation is disposed in the neighbourhood of the centre of the two plate-shaped electrodes, so that the ionizing region includes only a small central portion of the space between the electrodes and the two electrodes extend from the ionization region in all directions for a distance at least equal to five times their separation.

7. A fire-detector device in accordance with claim 6 wherein at least one electrode is carried by a central insulating post which is provided on its surface with ribs or projections to increase its leakage path.

8. A fire-detector device in accordance with claim 7 wherein the insulating post is secured to an insulating plate and the other electrode is secured by intervening supports to the insulating plate but does not touch the post.

9. A fire-detector device in accordance with claim 7 or 8 wherein the post is provided with a central bore containing a conductor by which one of the electrodes is connected to the input of a voltage-sensitive device mounted on the insulating plate.

10. A fire-detector device in accordance with claim 9 wherein said voltage-sensitive device is a field-effect transistor.

11. A fire-detector device in accordance with any one of claims 6 to 10 wherein means are provided in the region of the margin of the plate-shaped electrodes whereby the field strength of the electric field is locally increased.

12. A fire-detector device in accordance with claim 6 wherein the ionization chamber is bounded in the radial direction by a grid arranged to be electrically charged.

13. A fire-detector device in accordance with any one of the preceding claims wherein the radioactive source contains tritium.

14. A fire-detector device in accordance with any one of the preceding claims wherein the electrode shape and spacing and the potentials applied thereto are so chosen that the ionization chamber operates at least substantially within the saturation region as regards air ions but that no saturation is present as regards charged heavy particles.

15. A fire-detector device in accordance with any one of the preceding claims wherein the radioactive source is enclosed by radia-

tion absorbent material to limit the ionization range of the source.

16. A fire-detector device substantially as described with reference to Figures 2A to 2D or Figures 3A to 3D of the drawings.

A. A. THORNTON & CO.,
Chartered Patent Agents,
Northumberland House,
303—306 High Holborn,
London, W.C.1.

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1 432 531 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEET 1

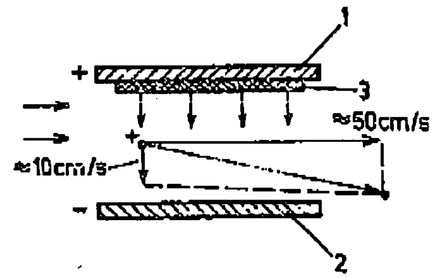

Fig.1

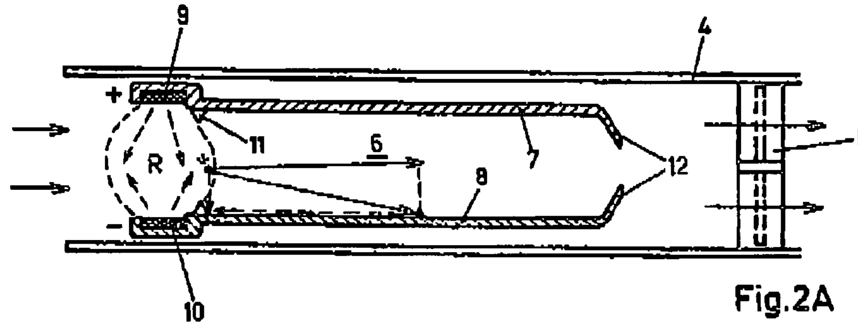

Fig.2A

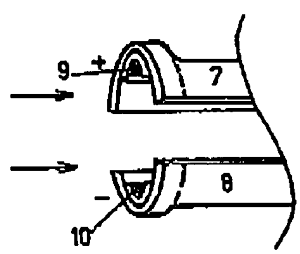

Fig.2B

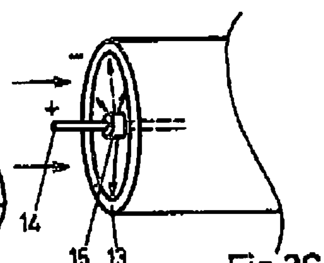

Fig.2C

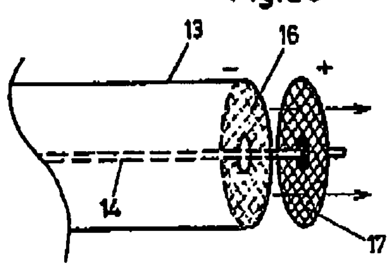

Fig.2D

1 432 531 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale.*
SHEET 2

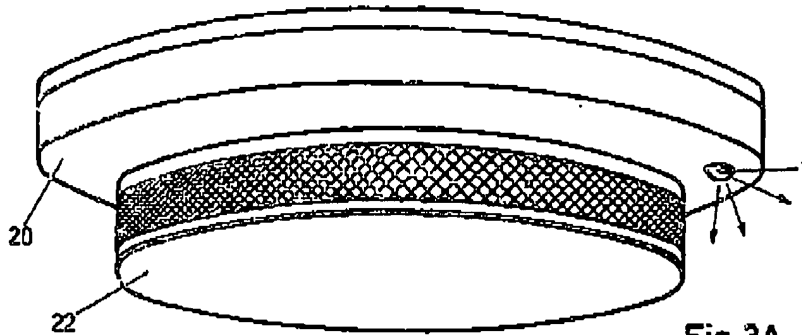

Fig.3A

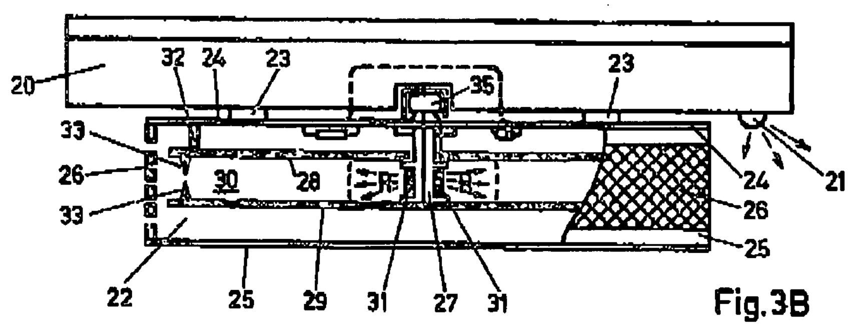

Fig.3B

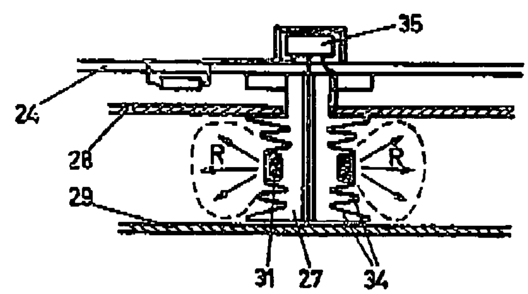

Fig.3C

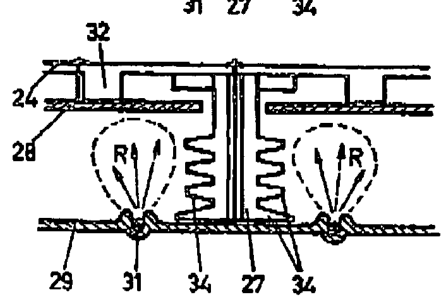

Fig.3D